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Transit Temperatures of Heavy Loads of

CALIFORNIA LETTUCE

Shipped in Several Types of Rail Equipment

MARKETING RESEARCH REPORT NO. 683
U.S. DEPARTMENT OF AGRICULTURE/AGRICULTURAL RESEARCH SERVICE

ACKNOWLEDGMENTS

The cooperation and assistance of the following organizations and firms are gratefully acknowledged:

The following shippers for providing test cars:

Admiral Packing Company
Bruce Church, Inc.
Bud Antle, Inc.
Christensen Bros.
Growers Exchange, Inc.
Harden Farms of California
Mutual Vegetable Sales
Salinas Valley Vegetable Exchange
The Garin Company

The Pacific Fruit Express Company, for assistance in obtaining icing records and supplying equipment.

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Washington, D.C. Issued November 1964

Transit Temperatures of Heavy Loads of California Lettuce Shipped in Several Types of Rail Equipment

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SUMMARY AND CONCLUSIONS

Transit temperatures of heavy loads of naked-pack (unwrapped) lettuce in mechanically refrigerated cars and in Ice Tempco[2] cars, shipped under different thermostat settings and different salting percentages, were compared to temperatures of conventional and heavy loads of lettuce shipped in general-service, ice-bunker refrigerator cars (RS) using normal hot weather salting (2 percent of the weight of ice added initially and 4 percent of that added at each re-icing).

Transit temperatures of both conventional (640 cartons) and heavy (704 cartons) loads in the RS cars averaged 37° F. Transit temperatures in three mechanically refrigerated cars of lettuce with 34° thermostat settings averaged 38°.

The conventional conditions for Ice Tempco cars (34° F. thermostat and 2 percent salt initially with 3 or 4 percent salt at each re-icing) resulted in an average transit temperature of 39°. Lowering the thermostat setting to 32° did not improve temperatures appreciably in the Tempco cars.

Increasing the salt from 2 and 4 percent to 3 and 5 percent in Tempco cars lowered transit temperatures slightly and did not cause dangerously low temperatures in the load. The extra salt increased the ice meltage, but none of the test cars ran out of ice in transit. However, the danger of doing so and the slight benefit discourage the use of 3 and 5 percent salting.

Temperatures were quite uniform throughout the loads in all types of cars tested.

Conventional salting percentages and thermostat settings during the summer months provided transit temperatures of heavy loads that were above the optimum holding temperature of 32° F. for lettuce--5 degrees above in RS cars, 6 degrees above in mechanical cars, and 7 degrees above in Ice Tempco cars. Load temperatures increased an average of 3 degrees in each of the three types of cars between midnight of the day of loading and time of arrival at destination. Additional studies should be conducted to try to improve transit temperatures of lettuce shipped in rail equipment, particularly by preventing the increase in load temperatures that generally occurs in transit.

BACKGROUND

Mechanically refrigerated rail cars and Ice Tempco cars have become readily available to western lettuce shippers in recent years.

The Ice Tempco car is a modified RS car in which one bunker has been removed and the other enlarged to hold 7,400 pounds of ice. This increases the inside length of an ice bunker car by about 3-1/4 feet and thus permits larger loads. The larger loads result in reduced freight charges per carton because of the new per-car rates and incentive rates for heavy loads. In addition to accommodating heavier loads, the Ice Tempco car has two sets of fans powered by a diesel engine. One set, which circulates air through the ice bunker to the load compartment, is regulated by an adjustable thermostat so that

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[2]Trade names are used in this publication solely for the purpose of providing specific information. Mention of the trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

either low or moderate temperatures can be maintained. The other set of fans operates continuously to circulate air, which bypasses the ice bunker, through the load.

Heavy loads also are used in mechanical cars and in the conventional RS cars to take advantage of the per-car rates and incentive rates for heavy loads. The mechanical cars used were of the semienvelope type with openings in the ceiling to permit the cold air to circulate directly through the load compartment.

The effectiveness of the Ice Tempco and mechanical cars was compared with that of the RS car in providing satisfactory transit temperatures for heavy loads of California naked-pack lettuce shipped during the warm season of the year. Thermostat settings and percentages of salt were varied in the Ice Tempco cars to determine the conditions providing optimum temperatures during transit in this equipment.

The study is part of a broad program of continuing research by the Agricultural Research Service to maintain the quality of farm products during the marketing period.

METHODS

Test cars were shipped to east coast markets from Salinas, Calif., from August 1 to September 19, 1962, and from July 10 to September 5, 1963 (table 1). Conventional RS cars, Ice Tempco cars, and mechanically refrigerated cars of lettuce were shipped during 1962, but only Ice Tempco cars were shipped during 1963. All test loads were of naked-pack lettuce, two-dozen size, packed in the standard lettuce carton, and placed in the conventional solid load pattern.

Three of the RS cars had about 640 cartons of lettuce, the number commonly used before incentive rates for heavy loads were in effect. The other three RS cars had 704 cartons, the number commonly used since the introduction of incentive rates. The three mechanical cars each had 980 cartons and the Ice Tempco cars had 768 or more cartons of lettuce (table 1).

All test loads were vacuum cooled and all iced cars were shipped under Standard Refrigeration. Transit temperatures were measured with recording thermometers placed in the center of lettuce cartons that were loaded at specific positions in the centerline of the cars. In RS cars, the thermometers were placed at the top, middle, and bottom layers, quarterlength, at one end of the car. In mechanical and Ice Tempco cars, the thermometers were placed at the same positions as in the RS cars, but at both ends of the car. Most of the Ice Tempco cars had thermometers attached to the ceiling of the car, one foot from the duct opening to record air-blast temperatures. Two or three cars were usually shipped on the same day to the same market area. A thermometer was attached under one car in each of these groups to record outside air temperatures during transit.

RESULTS

Effect of Car Type and Salting Practice on Transit Temperatures of Naked-Pack Lettuce

RS cars versus Ice Tempco cars.--Temperatures in conventional RS cars were compared to those in Ice Tempco cars during 1962. The usual commercial salting practice for RS and Ice Tempco cars of lettuce shipped from the Salinas, Calif., area during the warm season of the year is to add 2 percent of the bunker capacity at initial icing and either 3 or 4 percent of the amount of ice added at each re-icing. The thermostat on Ice Tempco cars is usually set at 34° F. for lettuce, but 34° and 32° settings were tested in combination with various percentages of salt to find the conditions providing the best commodity temperature in transit.

The average load temperature during transit of six conventional RS cars shipped during the summer of 1962 was 37° F. (fig. 1A). Load size did not influence the load temperature in these cars. The three cars with 704 cartons (cars 1, 6, and 16) averaged 37° in transit as did the three cars with 640 cartons (cars 9, 11, and 14) (table 2).

TABLE 1.--Description of lettuce test cars shipped from Salinas, Calif., 1962-63

Date shipped, and test car number	Type of car[1]	Inside length of car		Destination	Size of load
1962		Ft.	In.		Cartons
August 1:					
Car 1.....	RS	33	2-3/4	Boston, Mass.	704
Car 2.....	Ice Tempco	36	6	Washington, D.C.	768
Car 3.....	Ice Tempco	36	6	Newark, N.J.	768
August 8:					
Car 4.....	Ice Tempco	36	6	Newark, N.J.	768
Car 5.....	Mechanical	44	10	New York, N.Y.	980
Car 6.....	RS	33	2-3/4	New York, N.Y.	704
August 14:					
Car 7.....	Ice Tempco	36	6	Newark, N.J.	768
Car 8.....	Ice Tempco	36	6	New York, N.Y.	768
Car 9.....	RS	33	2-3/4	New York, N.Y.	640
August 22:					
Car 10.....	Ice Tempco	36	6	Newark, N.J.	768
Car 11.....	RS	33	2-3/4	New York, N.Y.	640
Car 12.....	Mechanical	44	6	New York, N.Y.	980
September 12:					
Car 13.....	Ice Tempco	36	6	New York, N.Y.	768
September 13:					
Car 14.....	RS	33	2-3/4	New York, N.Y.	636
September 19:					
Car 15.....	Mechanical	44	10	New York, N.Y.	980
Car 16.....	RS	33	2-3/4	New York, N.Y.	704
1963					
July 10:					
Car 17.....	Ice Tempco	36	6	New York, N.Y.	768
Car 18.....	Ice Tempco	36	6	New York, N.Y.	768
July 11:					
Car 19.....	Ice Tempco	36	6	Philadelphia, Pa.	768
Car 20.....	Ice Tempco	36	6	Philadelphia, Pa.	768
August 28:					
Car 21.....	Ice Tempco	36	6	New York, N.Y.	768
Car 22.....	Ice Tempco	36	6	New York, N.Y.	768
September 5:					
Car 23.....	Ice Tempco	36	6	New York, N.Y.	800

[1] RS is general-service ice-bunker refrigerator car.

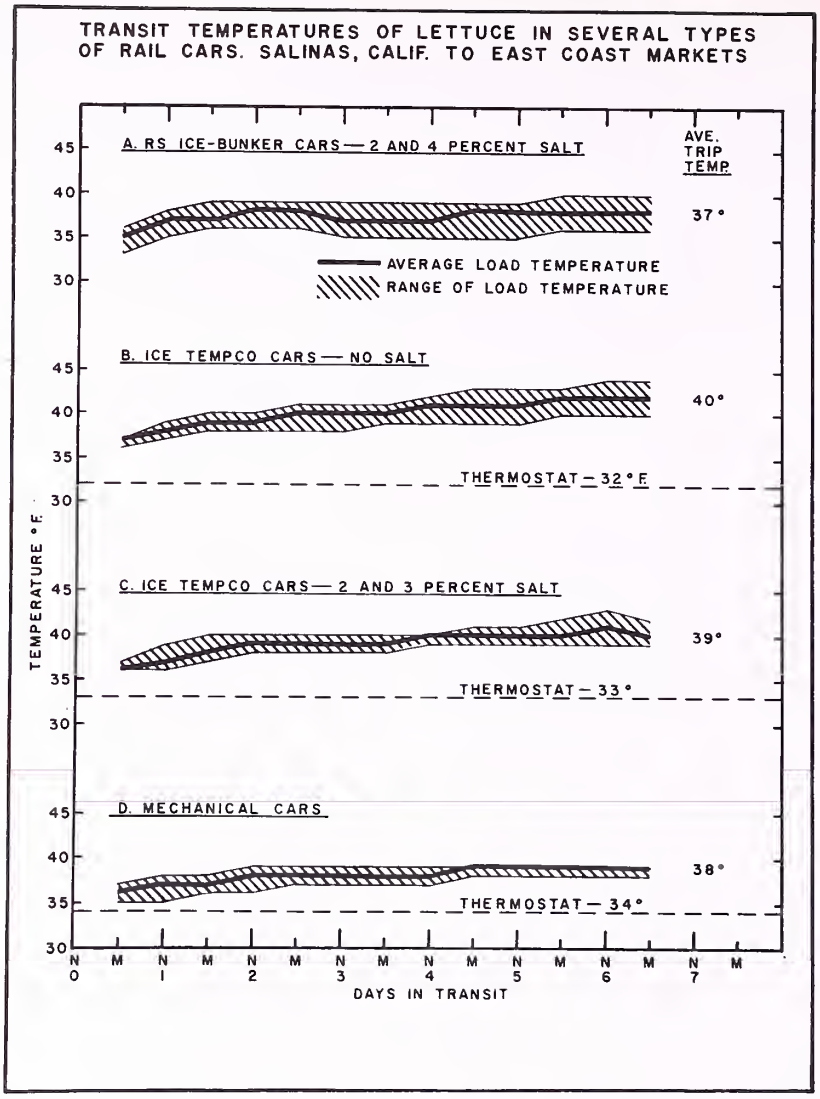

Figure 1.--Transit temperatures of naked-pack lettuce shipped during the summer of 1962. A.--Average of RS ice-bunker cars 1, 6, 9, 11, 14, and 16. B.--Average of Ice Tempco cars 2 and 7. C.--Average of Ice Tempco cars 3, 4, 8, and 10. D.--Average of mechanical cars 5, 12, and 15.

The average load temperatures during transit of two Ice Tempco cars (cars 3 and 8) shipped in 1962 under the conventional practice (2 and 3 percent salt and a thermostat setting of 34° F.) was 40° and 39° (table 3). Two Tempco cars of lettuce (cars 2 and 7) were shipped with a thermostat setting of 32° in an effort to improve transit temperatures. No salt was added to the bunkers of these cars, either initially or in transit, because of the low thermostat setting (table 3). The average transit temperature of these cars was 40° (fig. 1B). This practice was no improvement over that in which Tempco cars received 2 and 3 percent salt and had the thermostat set at 34° (cars 3 and 8). Two Tempco cars (cars 4 and 10) were shipped with 2 and 3 percent salt and a 32° thermostat setting in a further effort to reduce transit temperatures (table 3). The average transit temperatures of these two loads were 39° and 38°, about the same as temperatures in the two cars receiving the same salting, but with the thermostat set at 34°. Because of the small differences in transit temperatures and shipping conditions, transit temperatures for Ice Tempco cars 3, 4, 8, and 10 are averaged in figure 1C and table 4.

Ice Tempco cars using 2 and 4 percent versus 3 and 5 percent salt.--In another Tempco car shipped in 1962 (Car 13) 3 and 5 percent salt was used to try to improve transit temperatures. The average transit

Table 2.--Temperatures of lettuce loads in RS and mechanical cars shipped from Salinas, Calif., 1962

Type of car and test car number	Salt added[1]	Average lettuce temperatures in transit[2]			
		End of car		Car average	Range[3]
		A	B		
	Pct.	°F.	°F.	°F.	°F.
RS:					
1.....	2 & 4	37	--	37	1
6.....	2 & 4	--	37	37	2
9.....	2 & 4	--	39	39	1
11.....	2 & 4	36	--	36	1
14.....	2 & 4	37	--	37	2
16.....	2 & 3	--	38	38	4
Mechanical:[4]					
5.....	--	37	39	[5] 39	6
12.....	--	36	37	37	1
15.....	--	38	39	39	4

[1] First number represents the percent salt added initially (based on full bunker capacity) and the second number represents the percent salt added at each re-icing station (based on amount of ice added).
[2] Based on 6 1/2-day transit period.
[3] Range in average transit temperatures among the various positions in any one car.
[4] Thermostat setting was 34° on all mechanical cars.
[5] Car average temperature was obtained by averaging temperatures recorded by all 6 recording thermometers in load. Average of temperatures of opposite ends of car do not equal listed car average because of rounding.

temperature of the load in this car was 37° F., slightly lower than the temperatures obtained in the Tempco cars using less salt (table 4). To continue the study of the effect of salting in Tempco cars, four Tempco cars of lettuce were shipped to the east coast in 1963 with conventional salting of 2 and 4 percent and three were shipped with 3 and 5 percent salt. The data obtained from Car 13 shipped in 1962 with 3 and 5 percent salt are evaluated with these cars. The conventional thermostat setting of 34° was used in all these cars. The four cars receiving 2 and 4 percent salt averaged 39° in transit and the four cars receiving 3 and 5 percent salt averaged 38° (fig. 2).

The thermostat in Car 19 may have been out of calibration, as the average air-blast temperature and load temperature in transit were higher in this car than in any other Tempco car shipped with salt during 1962 or 1963 (table 3). Disregarding the unusually high temperature in Car 19, the transit temperature of the remining three cars receiving 3 and 5 percent salt averaged 37° F., 2 degrees cooler than the average of the cars receiving 2 and 4 percent salt and the same as the six RS cars shipped in 1962.

Air circulation, as judged by lettuce temperatures at the different positions in the load, was satisfactory in all Ice Tempco cars shipped during 1962 and 1963. These cars each had a metal air duct at the ceiling, extending from the ice bunker to the quarter-length at the opposite end of the car. Earlier tests with Tempco cars had shown that load temperatures differed appreciably in the two ends of the load compartment in cars without air ducts.[3] All such cars are now equipped with ducts. In the 14 Tempco cars tested in 1962 and 1963, average trip temperatures in the A and B ends of the individual cars were the same or differed by only 1 degree (table 3). Average trip temperatures at individual positions in the load

[3] Harvey, John M., Uota, M., and Kaufman, Jacob. Thermostatic temperature control for shipments of early-season Bartlett pears. U.S. Dept. Agr. AMS-476. 19 pp. 1962.

Table 3.--Air and lettuce temperatures in Ice Tempco cars shipped from Salinas, Calif., 1962-63

Thermostat setting, percentages of salt added,[1] and test car number	Average air blast temperature	Average lettuce temperatures in transit[2]			
		End of car		Car average	Range[3]
		A	B		
	°F.	°F.	°F.	°F.	°F.
32° setting:					
No salt:					
Car 2.....	--	41	42	[4] 41	1
Car 7.....	38	39	38	39	1
2 & 3% salt:					
Car 4.....	--	40	39	[4] 39	4
Car 10.....	36	38	38	38	1
34° setting:					
2 & 3% salt:					
Car 3.....	--	40	39	40	2
Car 8.....	--	39	39	39	3
2 & 4% salt:					
Car 18.....	36	38	38	38	1
Car 20.....	37	40	40	40	3
Car 21.....	37	39	39	39	1
Car 23.....	36	38	38	38	2
3 & 5% salt:					
Car 13.....	36	37	37	37	2
Car 17.....	36	38	37	38	2
Car 19.....	39	41	41	41	1
Car 22.....	--	37	37	37	2

[1] See footnote 1, table 2.
[2] Based on 6 1/2-day transit period.
[3] Range in average transit temperatures among the various positions in any one car.
[4] See footnote 5, table 2.

of a given Tempco car differed by only 1 to 4 degrees; the range averaged 2 degrees.

Air-blast temperatures in Ice Tempco cars with 34° F. thermostat settings averaged 2 degrees above the thermostat setting, disregarding Car 19 in which the thermostat appears to have been out of calibration. The average load temperature in each of these cars was 1 to 3 degrees above the air-blast temperature, and averaged 2 degrees higher.

No freezing temperatures occurred in any of the Ice Tempco cars receiving 3 and 5 percent salt. Previous tests[4] had shown 3 and 5 percent to be dangerous for lettuce shipped in RS cars, particularly during long stopovers when the fans were not operating. However, with the safety factors of a thermostat and continuously operating bypass fans, 3 and 5 percent salt was safe to use in the Ice Tempco cars.

RS cars versus mechanical cars.--Three mechanically refrigerated cars (Cars 5, 12, and 15) loaded with naked-pack lettuce were shipped during the summer of 1962 (table 2). With a thermostat setting on these cars of 34° F. the loads averaged 38° in transit (fig. 1D). This temperature was close to the average transit temperature of loads shipped in RS cars (fig 1A).

Average load temperatures in individual mechanical cars ranged from 3 to 5 degrees (averaging 4 degrees) above the thermostat setting. The average trip temperatures at the A and B ends of the mechanical cars were quite uniform, differing by only 1 or 2 degrees. Average trip temperatures at individual positions were quite uniform in two of the mechanical cars. However, in Car 5, the range in temperature was 6 degrees

[4] Barger, W. R., Stewart, J. K., Harvey, J. M., and others. Transit temperatures of California lettuce. U.S. Dept. Agr. Mktg. Res. Rpt. 285. 16 pp. 1958.

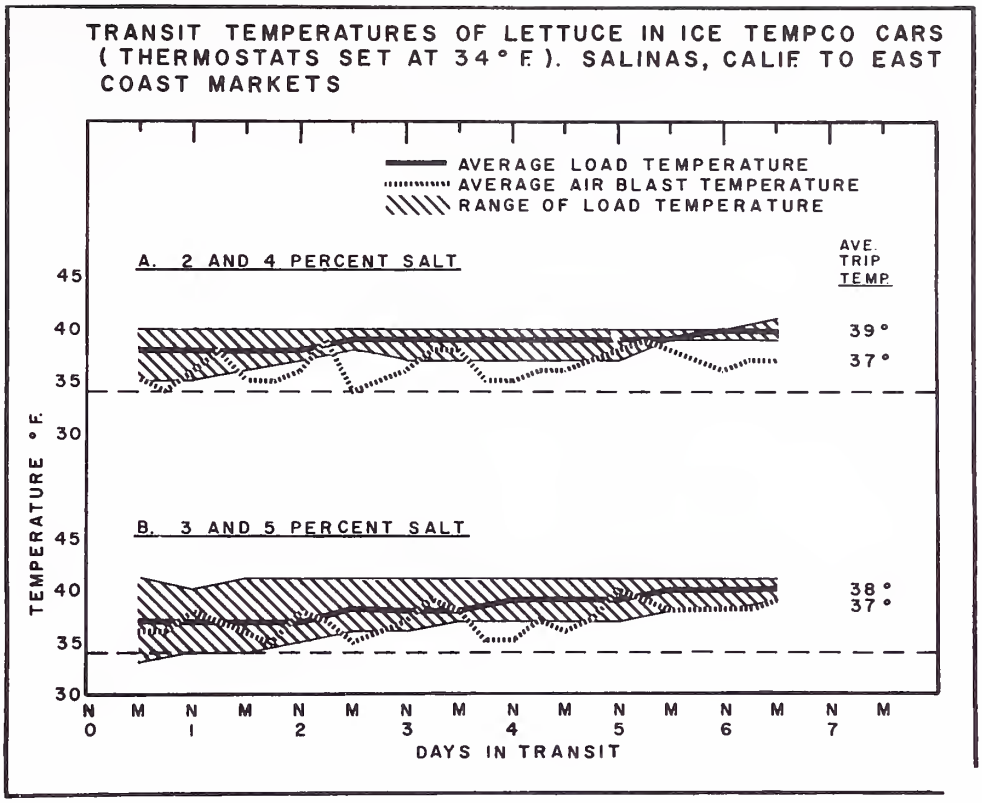

Figure 2.--Transit temperatures of naked-pack lettuce shipped during the summer of 1962 and 1963 under two different salting percentages. A.--Average of Cars 18, 20, 21 and 23 shipped with 2 percent initial salt and 4 percent salt at each re-icing. B.--Average of Cars 13, 17, 19, and 22 shipped with 3 and 5 percent salt (no air-blast record from Car 22).

between the warmest and the coolest positions.

Temperatures were not obtained at both ends of the RS cars because ice bunkers and fans were identical in each end. Average trip temperatures at the warmest and coolest positions in individual loads differed by only 1 to 4 degrees in the RS cars; the average difference was 2 degrees.

Ice Meltage in RS and Ice Tempco Cars During Transit

In 1963, the Ice Tempco cars receiving 2 and 4 percent salt melted an average of 23,700 pounds of ice per car during transit, while the Tempco cars receiving 3 and 5 percent salt melted an average of 25,700 pounds of ice per car (table 4). In 1962, ice meltage in Ice Tempco Car 13 and RS Cars 14 and 16 was relatively low, probably because of the cooler weather that prevailed during these test shipments (table 4).

The total ice meltage per car in Ice Tempco cars receiving 2 and 3 percent salt in 1962 averaged 1,800 pounds per car more than that of Ice Tempco cars receiving 2 and 4 percent salt in 1963, and about the same as the ice meltage in the Tempco cars receiving 3 and 5 percent salt in 1963. The greater meltage at the lower salting rates may have occurred because of the warmer nighttime temperatures during test shipments made in 1962 (table 4).

Several of the Ice Tempco cars shipped in 1962 and 1963 arrived in at least one re-icing station with only about one-half ton of ice remaining in the bunker. However, at no time did any of the test cars completely run out of ice.

Ice Tempco cars receiving 2 and 3 or 2 and 4 percent salt averaged about 3,000 pounds more ice meltage per car during hot weather transit to the east coast than conventional RS cars receiving 2 and 4 percent salt (table 4). This is an average of about 400 pounds more ice per day that melted in the Tempco cars than in the other cars. The greater ice meltage in Tempco cars than in RS cars may be partially explained by the greater amount of heat generated by the constantly operating bypass fans in Tempco cars than by the intermittently operating fans in the RS cars. Also, the bunker fans in the Tempco car ran at a relatively high speed when in operation.

TABLE 4.--Temperatures of lettuce loads and ice meltage in RS and Ice Tempco cars shipped from Salinas, Calif., 1962-63

Year of test, car type, and test car number	Salt added[1]	Initial load temperature	Average temperature in transit[2]			Bunker ice[4] (average per car)				
			Load[3]	Outside air		Supplied		Remaining at destination	Melted during transit	Average melted per day
				Av. low	Av. high	Initial	In transit			
1962	Pct.	°F.	°F.	°F.	°F.	lb.	lb.	lb.	lb.	lb.
RS:										
1, 6, 9, 11.....	2 & 4	34	37	65	93	11,100	17,500	7,000	21,600	3,100
14, 16.....	[5] 2 & 4	34	38	51	80	10,800	13,400	8,800	15,400	2,200
Ice Tempco:										
2, 7.....	0 & 0	33	40	68	96	7,400	20,700	2,600	25,500	3,600
3,4,8,10.....	2 & 3	34	39	65	93	7,400	21,000	2,900	25,500	3,600
13.....	3 & 5	32	37	52	86	7,400	15,900	5,000	18,300	2,600
1963										
Ice Tempco:										
18, 20, 21, 23.....	2 & 4	34	39	60	92	7,400	19,100	2,800	23,700	3,400
17, 19, 22.....	3 & 5	35	39	60	93	7,400	20,800	2,500	25,700	3,700

[1] See footnote 1, table 2.
[2] Based on 6 1/2-day transit period.
[3] See text for number and location of thermometers in loads.
[4] All ice weights rounded off to nearest 100 pounds. Ice meltage per day based on 7-day period.
[5] Car 16 received 2 and 3 percent salt.